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THE EVOLUTION OF THE TERTIARY MAMMALS, AND THE IMPORTANCE OF THEIR MIGRATIONS[1]

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NOTE.—These very interesting and important papers by Charles Depéret, Dean of the Faculty of Science, University of Lyons, France, have been especially revised by the author (to date, November, 1907) before translation. The translation is the work of Miss Johanna Kroeber, graduate student of Columbia University. Dr. Charles R. Eastman of Harvard University and Dr. W. D. Matthew of the American Museum have kindly revised the translation. The correlation of the Tertiary of the Old and New World is of such commanding interest to paleontologists, zoologists and geologists, that this contribution from one of the foremost paleontologists of the continent is especially welcome.

HENRY FAIRFIELD OSBORN.

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FIRST PAPER. EOCENE EPOCH

In a preceding contribution (*Comptes rendus,* 5 juin, 1905) upon the principles of evolution of the Tertiary mammals, I have enunciated the following general law: that when we attempt to establish the sequence of the forms which represent the evolution of a *natural phylum* we find ourselves, after tracing them backward through a geologic series of more or less length, almost always arrested by an impassable hiatus; this *apparent break* corresponds to the sudden appearance of the group under consideration in the region of the globe which one is studying.

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[1] Extract from the *Comptes rendus des séances de l'Académie des Sciences,* t. CXLI, p. 702. (Séance du 6 novembre, 1905.) Translated by Johanna Kroeber.

It is desirable to return to this general law of *faunal changes through migration* and to illustrate its interest more fully.

The importance of the migrations of terrestrial animals as correlated with great changes in the *paleogeography* of the continents, was fully recognized a century ago by Cuvier. The illustrious founder of paleontology had been justly impressed by the absence or rarity of forms of passage between the superposed fossil faunæ. Exaggerating somewhat, owing to the imperfect evidence before him, the consequences of this observed fact, Cuvier had deduced from it the renewal of faunæ *in toto* (after their destruction by *terrestrial cataclysms*) not by successive *creations,* as he is often accused of advocating, but by extensive *migrations* of animals foreign to the region. Since his time, many paleontologists, Wallace, Lydekker, Zittel, Schlosser, Gaudry, Osborn, Ameghino, etc., have given their attention to this subject and have reiterated its significance. It appears to me, however, that these contributions have been of too speculative a character, inadequately supported by precise data. It has resulted that the majority of the essays at the *genetic* or *structural phylogeny,* which have been attempted in various groups of fossil mammals, are defective, chiefly because their authors have almost always sought to find in place in the particular country which they inhabit the various evolutionary series of these groups.

No doubt there are great practical difficulties in refastening link to link the segments of the broken chain which forms the evolutionary series of each of the innumerable branches of the mammalia. Nevertheless, the obstacles are smoothed away by each new discovery; thus the recent disinterment of the Oligocene and Eocene of the Libyan desert, of the ancestors of the Proboscidea, the Mastodons and Dinotherium, which appear so suddenly in Europe at the beginning of the Miocene, and whose origin has been until now an insoluble enigma, indicates the method we should follow, and the necessity for searching for the *centers of dispersion* of each branch.

A preliminary work at least is possible at our present stage of knowledge; it is to establish for each region whose paleontologic exploration is sufficiently advanced, the part which pertains to each of the two factors determining faunal changes: (1) *Evolution of the local fauna* (autochthonic evolution), (2) *Immigrations from a distant region.*

I shall attempt to analyze these facts for the Tertiary faunæ of Europe, where this distinction has never been established in a systematic manner.

I. *Thanetian* or *Lower Londinian* stage (deposits of la Fère, Cernay, Rilly, Châlons-sur-Vesle in France; of Erquelines in Belgium).

1. *Local Evolution.*—A single instance, *Neoplagiaulax* (Multituberculata), which may perhaps have been derived, in spite of the great gap of the Cretaceous, from *Plagiaulax* of the Purbeck, but may also have migrated from North America.

2. *Migrations of North American Origin.*—Introduction into Europe of several families of Creodonta: Oxyclænidæ (Procynictis = Chriacus), Arctocyonidæ (Conaspidotherium = Clænodon), Mesonychidæ (Dissacus); and of the Condylarthra (Euprotogonia).

3. Migrations of unknown origin of the Insectivora (Adapisoricidæ), of the (?) Artiodactyla (Pleuraspidotheriidæ), of the aberrant Primates of the group Plesiadapidæ, of the Perissodactyla (Hyracotheriidæ or Preequidæ), of the Amblypoda (Coryphodon).

II. *Sparnacian* or *Upper Londinian* stage (deposits of Soissons, Guny, Muirancourt, Saron near Ste Maxence, Laon, Upper Cernay, Meudon, Vaugirard, Sézanne, in France; Dulwich and Croyden (Woolwich beds) in England. Fauna unfortunately still very scanty.

1. *Local Evolution.*—Continuance of Amblypoda (Coryphodon, and of Hyracotheriidæ (? Pachynolophus).

2. *North American Migrations* of certain Creodonta (Pachyæna, Palæonictis).

III. *Lower Ypresian* stage (beds of the London Clay, Herne Bay, Kyson, Harwich, Isle of Sheppey, in England; beds of Pourcy near Reims in France). Fauna little different from that of the preceding stage.

1. *Local Evolution.*—Continuance of Amblypoda (Coryphodon), and of Hyracotheriidæ (Hyracotherium).

2. *Migration of North American Origin* of the Tillodontia (Platychærops = Esthonyx).

IV. *Upper Ypresian* stage (beds of Teredo-sands, Ay, Cuis, Chavot near Epernay).

1. *Local Evolution.*—Continuance of Insectivora (Adapisoriculus), of aberrant Primates (Plesiadapis), of Creodonta-Mesonychidæ (Hyænodictis = Dissacus), and of Hyracotheriidæ (Propachynolophus).

2. *Important Migrations, Probably of North American Origin,* of the mesodont Primates (Notharctidæ, genus Protoadapis), of the Rodentia-Pseudosciuridæ (Decticadapis), and Sciuridæ (Plesiarctomys), of Lophiodontidæ (parallel branches Lophiodon and Chasmotherium), of the Paridigitate Suillines (Protodichobune) and perhaps of Titanotheridæ (Brachydiastematotherium).

This horizon is marked by some important migrations and great changes in the mammalian fauna, in consequence of which the latter approximate more closely to the fauna of the middle, than to that of the lower Eocene.

V. *Lutetian* stage, two successive faunæ:

(*a*) *Lower* and *middle Lutetian* (beds of Argenton, of Bracklesham and part of the "terrain sidérolithique" of Egerkingen and of Lissieu).

Local evolution of Lophiodontidæ (Lophiodon, Chasmotherium), of Hyracotheriidæ (Pachynolophus, Propalæotherium) and of Dichobunidæ (Meniscodon, Dichobune).

(*b*) *Upper Lutetian* ("Calcaire grossier" beds of Paris: Nanterre, Vaugirard, Gentilly; Coucy, Dampleix; of Buschweiler, of Issel; les Matelles, St. Gily du Tesc;

the larger part of the "terrain sidérolithique" of Egerkingen and of Lissieu).

1. *Local Evolution.*—Continuance of Lophiodontidæ (Lophiodon, Chasmotherium), of Hyracotheriidæ (Pachynolophus, Propalæotherium, and intermediate forms leading to Lophiotherium), of Creodonta-Oxyclænidæ (Proviverra), of Rodentia-Sciuridæ (Plesiarctomys), of Dichobunidæ (Dichobune, Mouillacitherium), and of the mesodont Primates (Cænopithecus, ? Adapis).

2. *Important Migrations of Unknown Origin* of the Palæotheriidæ (appearing suddenly with their two branches Palæotherium and Plagiolophus), the Anchilophidæ (Anchilophus), the Suidæ (Chœromorus, Acotherulum), the Anthracotheriidæ (Catodontherium n. g., forerunner of Brachyodus), the Dacrytheridæ (Dacrytherium), the Xiphodontidæ (Xiphodontherium), the Dichodontidæ (Dichodon, Tetraselenodon, Haplomeryx), some Sciuridæ (Sciurus), the Talpidæ (Amphidozotherium), the Erinaceidæ (Neurogymnurus).

3. *North American Migrations* of the Hyænodontidæ and probably of the Lemuroidea-Anaptomorphidæ (Necrolemur).

VI. *Bartonian* stage (calcareous deposits of St. Ouen near Paris) of Sergy (Aisne), sandstones of Castrais (Lautrec, Mazou, Viviers, Montespien, etc.), of Robiac (Gard), "terrain sidérolithique" of Heidenheim and part of those of Mormont; very small part of the phosphorites of Quercy.

1. *Local Evolution.*—Continuance of Lophiodontidæ (last of Lophiodon and Chasmotherium), of Hyracotheriidæ (primitive representatives of Lophiotherium), of Palæotheriidæ (numerous parallel branches), of Anchilophidæ (Anchilophus), of Anthracotheriidæ (Catodontherium n. g.), of Suidæ (Chœromorus, Chœropotamus), of Xiphodontidæ (Xiphodontherium), of Creodonta (Hyænodon), of Sciuridæ (Plesiarctomys), of Adapidæ (Adapis).

2. *Migration, perhaps of North American Origin,* of the Chalicotheriidæ (Pernatherium).

VII. *Ludian* stage, two successive faunæ:

(*a*) *Lower Ludian* (deposits of Saint Hippolyte de Caton (Gard), of Hordwell (Isle of Wight), lower strata of the Gypse de Paris; part of the Quercy phosphorites.

1. *Local Evolution.*—Continuance of Palæotheriidæ, of Hyracotheriidæ (last of Lophiotherium), of Anchilophidæ, of Suidæ (Chœropotamus, Cebochœrus), of Dacrytheridæ (Dacrytherium), of Xiphodontidæ (Amphimeryx), of Dichodontidæ (last of Dichodon), of Anthracotheriidæ (Catodontherium), of Hyænodontidæ (Hyænodon, Quercytherium), of mesodont Primates (Adapis) and Anaptomorphidæ (Microchœrus).

2. No new migration known.

(*b*) *Upper Ludian* (Gypse de Montmartre, deposits of Gargas, of Mornoiron, of Villeneuve la Comptal; of the Bembridge beds and the Headon beds in England; part of the phosphorites.

1. *Local Evolution.*—Continuance of Palæotheriidæ, of Anchilophidæ (last of Anchilophus), of Xiphodontidæ (Amphimeryz, Xiphodon), of Dacrytheridæ (last of Dacrytherium), of Anthracotheriidæ (first representatives of Brachyodus, earliest Anthracotherium), of Suidæ (last of Acotherulum, Chœropotamus, and Cebochœrus), of Dichobunidæ (last of Dichobune), of Hyænodontidæ (Hyænodon, Pterodon), of Sciuridæ (Plesiarctomys, Sciurus), of Adapidæ (last of Adapis), of the Lemuroidea (last of Necrolemur).

2. *Migrations of Unknown Origin* of the Anoplotheridæ (Anoplotherium), of the Cænotheridæ (Oxacron = Hyœgulus), of the Canidæ (Cynodictis), of the Rodentia-Theridomyidæ (Theridomys), and Myoxidæ (Myoxus).

3. *American Migration* of the Marsupial Didelphyidæ (Peratherium).

(*To be continued.*)